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Six research studies involving computer assisted instruction (CAI) are reported. "Gradient and Full-Response Feedback in Computer-Assisted Instructions" did not substantiate the hypothesized advantages of gradient-response over full response feedback on the basis of amount learned (n=24). "Relative Effectiveness of Various Modes of Stimulus Presentation through Computer-Assisted Instruction" reported no significant differences for audio, typed, or display modes of presentation, but all three were significantly better than no instruction (n=90). "Expressed Student Attitudes under Several Conditions of Automated Programed Instruction" reported the use of "contingent prompting and feedback" and "knowledge of correct response" computer-assisted instruction and a programed text all containing the same program with 66 students in grades 9 and 10. A 40-item attitude scale revealed both methods resulted in significantly greater positive attitude than did the programed text. "Remedial and Review Branching in Computer-Assisted Instruction" contrasted branching and nonbranching programs. Results from 42 students indicated no differences in learning but the branching program required more time. Two projects which are in progress on "Numerical and Verbal Aptitude Tests Administered at the CAI Student Station" and "CAI Time Accounting and Usage Analysis" are reported. VT 005 978 is a similar report. (EM)

C·A·I

COMPUTER ASSISTED INSTRUCTION LABORATORY

COLLEGE OF EDUCATION · CHAMBERS BUILDING

THE PENNSYLVANIA STATE UNIVERSITY · UNIVERSITY PARK, PA.

EXPERIMENTATION WITH

COMPUTER-ASSISTED INSTRUCTION IN

TECHNICAL EDUCATION

SEMI-ANNUAL PROGRESS REPORT

JUNE 30, 1967

Report No. R-6

The Pennsylvania State University

Computer Assisted Instruction Laboratory
University Park, Pennsylvania

Semi-Annual Progress Report

EXPERIMENTATION WITH COMPUTER-ASSISTED INSTRUCTION IN TECHNICAL EDUCATION

Project No. 5-85-074

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June 30, 1967

Report No. R-6

FOREWORD

This report marks the end of the second year of a four-year research and development effort into one of the relatively unexplored new technologies of education. A good part of our first year was spent in learning how to manipulate, program, and maintain unfamiliar equipment. During the second year just ended, we have increased the number of curriculum segments available for technical education learners at the CAI terminal, investigated some of the research questions of greatest interest, and expanded our CAI teleprocessing system to include two terminals at our sister institution, the Williamsport Area Community College, as well as two terminals on the Altoona Campus of the University.

Unfortunately, due to budget cuts for the current fiscal year, we have reluctantly had to withdraw the terminals from Williamsport and Altoona. Both institutions provided us with unstinting cooperation in the selection of technical education students who served as subjects. The faculties of both schools gave us many hours of valuable consultation on curriculum and display problems. The executive officers of our two cooperating institutions, President Kenneth Carl at the Williamsport Area Community College and Mr. Robert Eiche, Director of The Pennsylvania State University at Altoona, have been patient, supportive, and understanding of the special requirements for educational research. For their help we are most grateful. Mention should be made of the efforts of Mr. George Wolfe at Williamsport and Mr. Robert Smith at Altoona who bore the brunt of our unreasonable demands and good-humoredly tolerated our intrusions into the calm of their academic lives.

During the next twelve months we will be primarily in another "hardware" phase as we accommodate to the new IBM 1500 Instructional System. Delivery is anticipated in November, but the spring of 1968 should find us producing research on some new questions after translating a significant portion of the curriculum into Coursewriter II codes and adapting displays to the cathode ray tube.

Harold E. Mitzel
George L. Brandon

University Park, Pennsylvania
June 30, 1967

CONTENTS

GRADIENT- AND FULL-RESPONSE FEEDBACK
IN COMPUTER-ASSISTED INSTRUCTION

Keith A. Hall, Marilyn Adams, and John Tardibuono

It is not appropriate at this point of development to maintain that computer-assisted instruction (CAI) can or does provide more instruction that is more efficient or effective than conventional methods. However, it is appropriate to scrutinize the particular characteristics of a given system to determine whether or not there can be or is improvement in learning. Many of these characteristics or variables cannot be judged in terms of previous experimentation in the field of educational psychology because they exist only in CAI. Further, studies conducted in laboratory situations cannot be readily transferred to an educational environment. This study attempted to remove one learning experiment from the artificial world of animal laboratories and nonsense syllables and to place it in an educational context.

Lumsdaine (1962) suggested two or three important gradients in programed instruction, one of which is an intraframe gradient involving the possibility of progressively increasing prompt strength within a frame from zero to the point at which the student is able to respond. Exploratory experimentation by Angell and Lumsdaine (1961), Israel (1960), and Guthrie and Lumsdaine (1961) suggested that a satisfactory way of adjusting these gradients might require instrumentation with considerable versatility; this is one of the areas in which experimentation with computer-assisted instruction might be of considerable interest. Angell and Lumsdaine (1960) also found that complete prompting was not entirely desirable. Their results showed that, contrary to the interpretation of previous data, learning was significantly more efficient under the condition of incomplete or aperiodic prompting (prompting on three out of four trials) than under conditions of complete prompting.

The Coursewriter language used at Penn State University in the development of CAI course materials has two functions (among others) for providing feedback to the student regarding the correctness of his response. Each of the functions gives the author flexibility in selecting the type of feedback to provide the student. The two functions under investigation were keyword (kw) and partial-answer zero (pa0). The kw function can be used to match a student's response against a stored correct response which may be a complete word or several complete words. The pa0 function causes the system to match a student's response against the stored correct response, one or more characters at a time, depending upon the author's choice. In each case feedback can be given to the student based upon what was and/or was not matched.

The simplest form of feedback with kw is the complete response which the student should have made. The simplest form of feedback with pa0 consists of the characters which matched correctly, dashes for lowercase characters which did not match, and underscores for uppercase characters which did not match. A typical student-system interaction with pa0 and kw is shown in Figure 1. It should be noted that all student responses here are italicized. The CAI system typed everything else which appears in the example. In the first instance, the computer presented the stimulus item "North Dakota" to which the student should respond with the state capital. In the partial-answer processing example, the student first responded with *Raleigh*. The system matched this response character by character against the stored correct response and typed an underscore for the missed capital letter, dashes for the other missed letters, and the letters applicable to the correct programed response rearranged in appropriate order. A frequency count of the characters in all of the correct responses in the program indicated that typing *clues and hints* or *more clues and hints* would provide most of the essential characters for the student in his answer. The students were told to type one of these phrases if they could not think of the correct answer. The student then was presented with a few of the characters in the correct response. Notice that the character r which he had matched previously was not included in *clues and hints* and therefore did not appear in the feedback from the computer. After the student typed *more clues and hints*, he was given sufficient feedback to enable him to type the correct answer.

Partial-Answer Processing	Keyword
North Dakota	North Dakota
*Raleigh**	*Pierre*
_i--ar--	Bismarck
clues and hints	*Bismark*
_is-a-c-	Bismarck
more clues and hints	*Bismarck*
_ismarc-	
Bismarck	
Wisconsin	Wisconsin
Racine	*(EOB)* (No typewritten response)
_a-i--n	Madison
clues and hints	*Madison*
_adis-n	
Madison	
Oklahoma	Oklahoma
Oklahoma City	*Oklahoma City*
:	:
:	:
:	:

Acquired: 8 Total Trials: 50 Total Responses: 94

Time: 49608.08 seconds Total response time: 794.66

*Italics indicate the responses typed by the student; all other material was typed by the CAI system to the student.

Fig. 1. Sample of student-systems interaction on partial-answer processing and keyword experimental treatments.

Looking at the same sequence in the kw treatment, the student typed *Pierre* and the system responded with the word "Bismarck." The student was then required to type the correct response before he could proceed to the next stimulus items. However, on the student's first attempt he misspelled the word; therefore he got the same feedback and had to retype the response.

The desirability of less than complete prompting found by Angell and Lumsdaine (1960) and the suggestion of providing a prompt based on the ability of the student to respond correctly (Lumsdaine, 1962) are variables potentially of great importance for improving instruction. However, the specific technique of adjusting the variables have not been adequately investigated. This is due in part to the lack of technology to properly manipulate the instructional sequence. The characteristics of the pa0 and the kw function provide the necessary control and flexibility.

Method

Stimulus Materials

Programs were written for investigating the effectiveness of these two kinds of feedback -- gradient and full-response feedback. The flowchart for the courses used in the experimental treatments is presented in Appendix A. The programing and flowchart for a specific question appears in appendices B, C, and D. A paired-associate learning task was employed using fifty pairs which the student learned. The fifty state names of the United States were presented as stimulus items, and the student learned to respond with the names of the capitals.[1] The items were presented individually, in random order, to the student at the typewriter terminal. If the student responded correctly (acquired) on his first attempt to that stimulus, it would be dropped from the program. The program recycled until each student had responded correctly on his first attempt to each of the items during

[1]The authors deliberately chose a learning task about which the subjects would have some partial information prior to the experiment. This choice of material parallels a typical classroom learning situation because learners are rarely ever completely ignorant of a subject taught to them in classrooms.

one cycle. The number acquired on the first cycle through the program was used as a pretest score. After the student acquired each of the fifty pairs, the entire list was presented as a posttest. A retention test was administered to each student two weeks after the initial treatment. The program for each of the experimental treatments contained the following features:

1. A list of warm-up items consisting of five foreign countries presented as stimuli and their capitals as response items.

2. A typing test which recorded the student's time and accuracy in typing an alphabetic sentence consisting of 74 computer characters. (A sample of student-system interaction on the typing test is presented in Appendix E.)

3. A progress report to the student after each cycle (see Figure 1) consisting of

   a. total number of responses
   b. total number of stimuli presented
   c. total number of items acquired
   d. total response latency
   e. current clock reading

4. An automatic 5-minute break approximately halfway through the task.

5. An automatic connection to a system-administered student opinion survey (SOS) regarding CAI.

Subjects

On the basis of variability data collected during a pilot study, it was estimated that a minimum of ten subjects in each experimental group would be needed for statistical purposes (Hayes, 1965). A total of 24 students from the Williamsport Area Community College and the Altoona Campus of the University were included in the study and were randomly assigned to the experimental treatments. Remote terminals are maintained at each of these locations for the purpose of conducting experimental studies which involve vocational and technical education students. Proctors who administered and supervised the students at these locations were given specific instructions to read to the students participating in the study.

Procedures

CAI proctors from the two campuses solicited volunteers to participate in the experimental study. The students were told that the study would require a maximum of four hours and that they would be paid a flat rate of $5.50 regardless of how much actual time it took them to complete the study. The students were randomly assigned to one of the experimental treatments. The proctors assisted the students with the initial registration procedure. The students' typeouts were returned to the authors for analysis.

Variables

The following summarizes the variables and their parameters which were of concern in this study:

1. Pretest, posttest, and retention tests: all contained the same items -- the names of the 50 states of the United States with a possible high score of 50 and a possible low score of 0.

2. Total number of stimuli presented: fifty stimuli (state names) were presented to each subject on the first cycle through the material. Those to which he responded correctly on his first attempt were not presented again. Those to which he responded incorrectly were retained and presented again during the next cycle of the program. The minimum number presented was 50; the maximum was unlimited, determined by each subject's performance.

3. Total number of responses during instruction: each time a stimulus was presented a response was required from the subject. Feedback was presented after each incorrect response and additional responses were required until the correct response was made. The minimum number of responses was 50; the maximum was unlimited but based on each subject's performance.

4. Total instructional time: includes the elapsed time from when the first item was presented until the final correct response was made.

5. Student opinion survey: a 20-item multiple choice questionnaire. Each response was weighted from five to one to produce a maximum score of 100 reflecting a strong favorable attitude toward CAI or a minimum score of 20 reflecting a strong negative attitude toward CAI.

6. Response latency during instruction, posttest, and retention test: After each stimulus item was presented a green PROCEED light turned on. The PROCEED light remained on until the subject pressed the EOB key to record his response. The time interval that the PROCEED light was on was recorded as the response latency for that item. The sum of these intervals was the total response latency accumulated during instruction, the posttest, and retention test.

Findings

Table 1 includes the total states presented, total responses, total teaching time, and the student opinion survey mean score for the two experimental treatments. It can be seen from this table that there was very little difference in the two treatments based upon all of these criteria except total instructional time. Although there is some difference in the total number of states presented, there is virtually no difference in the total number of responses made in each experimental treatment. This means that in the gradient feedback treatment the student was responding more often to the same stimulus, but it was not necessary to present the stimulus as often as was required for the students in the full-response feedback program.

An adjusted analysis of variance using the pretest scores as a covariant (Table 2) was performed on total instruction time. The pretest correlated -.847 with total instructional time. The analysis produced an F ratio of 15.3 which was significant beyond the .01 level.

Table 3 presents the mean score, mean response latency with standard deviations and adjusted mean scores of the independent adjusting variables and the dependent variables for treatment groups. For the analysis of the posttest data, the pretest scores and the typing scores were used as covariants in an analysis of covariance. A Kuder-Richardson formula 20 reliability estimate of .725 was found for the posttest. The pretest correlated .468 with the posttest; the typing test correlated .403 with the posttest. The adjusted analysis of variance for the posttest scores resulted in an F ratio of less than unity which was not significant.

An adjusted analysis of variance was also performed on the retention test scores (Kuder-Richardson formula 20 reliability estimate of .893) using the posttest and the typing test as covariants. The posttest correlated .675 with the retention test, and the typing test correlated .592 with the retention test. This analysis resulted in an F ratio of 1.44, which does not reach significance at the .05 level of significance.

Table 1

Total Stimuli Presented, Total Responses, Total Instructional Time, and SOS Mean Score for the Two Experimental Treatments

	(Gradient-response Feedback) Mean N=12	S.D.	(Full-response Feedback) Mean N=12	S.D.
Total No. of Stimuli Presented	99.33	28.67	110.58	45.46
Total No. of Responses	180.42	75.48	178.00	94.88
Highest	288		378	
Lowest	70		70	
Total Instructional Time in Minutes	98.72	38.64	75.80	32.18
SOS Score	72.58	6.43	72.75	8.37

Table 2

Adjusted Analysis of Variance for Instructional Time with the Effects of Prior Knowledge Removed

Source	Adjusted d.f.	Adjusted Sum of Squares	Adjusted Mean Square	F ratio
Treatment	1	3682.75	3682.75	15.3*
Error	21	5051.02	240.52	
Total	22	8733.77		

*Significant at the .01 level

Table 3

Mean Score, Mean Response Latency, with Standard Deviations and Adjusted Mean Scores of Independent Adjusting Variables and Dependent Variables for Treatment Groups

Variables for Treatment Groups	Gradient Feedback (n=12)					Full-Response Feedback (n=12)				
	Mean Score	S.D.	Adjusted Mean Score	Mean Response Latency (in seconds)	S.D.	Mean Score	S.D.	Adjusted Mean Score	Mean Response Latency (in seconds)	S.D.
Pretest[a]	19.58	12.08				18.83	13.68			
Posttest[a]	43.25	4.16	43.63[c]	16.41	6.97	44.58	4.74	44.21[c]	11.76	3.02
Retention[a] (2 weeks later)	36.92	8.24	38.40[d]	20.58	13.13	37.08	6.63	35.60[d]	12.67	5.23
Typing[b]	1.88	1.01				2.39	1.10			

[a]Maximum Score = 50; minimum score = 0

[b]Typing "score" was derived by dividing accuracy (number of letters and spaces correct) by time in seconds

[c]With the effects of prior knowledge and typing skill removed

[d]With the effects of after-treatment knowledge and typing skill removed

Discussion

Although no differences in learning (as measured by a performance test) were found between the experimental treatments, students can learn via computer-assisted instruction as evidenced by the mean on the pretest (19.21) and the mean on the posttest (43.91). The decrease in variability between pretest (s.d. = 12.62) and posttest (s.d. = 4.41) further indicates that students can achieve at least partial mastery of the material via CAI.

Many problems occur in conducting experimental studies with human subjects in remote locations. Scores on retention tests administered three months after the initial learning (not reported in this paper) were considerably higher than scores on the two-week retention test. In discussing this matter with the proctors, it was discovered that the size of the small campuses apparently enabled the "grapevine" among subjects to be very fast and very effective.

Other data collected during the course of the experiment seem to indicate that perhaps there were differences between the treatment groups. Table 4 presents the correlations of posttest scores and pretest scores, response latency during learning, total responses during learning, teaching time, and response latency during posttest for each experimental treatment. These are all variables which have potential for indicating learning in addition to posttest scores.

The correlations between retention test scores and all other variables which might indicate other aspects of learning is presented in Table 5. There is very little difference in the correlations produced by the two treatments except in the response latency for posttest and response latency during learning. A scatter diagram of the response latency for posttest revealed very little information. However, a scatter diagram (Fig. 2) of the retention test scores and response latencies during instruction for subjects in the gradient feedback and full-response feedback treatment groups indicated that the full response feedback produced much stronger readiness to respond than did the gradient feedback treatment. The correlation between retention test scores and total response latency during instruction of -.505 for the full-response feedback treatment group and

Table 4

Correlations Between Posttest Scores and Pretest Scores,
Response Latency during Instruction,
Total Responses during Instruction, Teaching Time, and
Response Latency during Posttest for Each Experimental Treatment

	Correlations Between Posttest Scores and:				
	Pretest	Response Latency: Instruction	Total Responses: Instruction	Instructional Time	Response Latency: Posttest
Gradient Feedback (n=12)	.382	-.492	-.439	-.516	-.313
Full-Response Feedback (n=12)	.553	-.480	-.497	-.512	-.091

-.229 for the gradient feedback group suggests that when full-response feedback is used, response latency can be a fairly good measure of student progress.

Conclusions

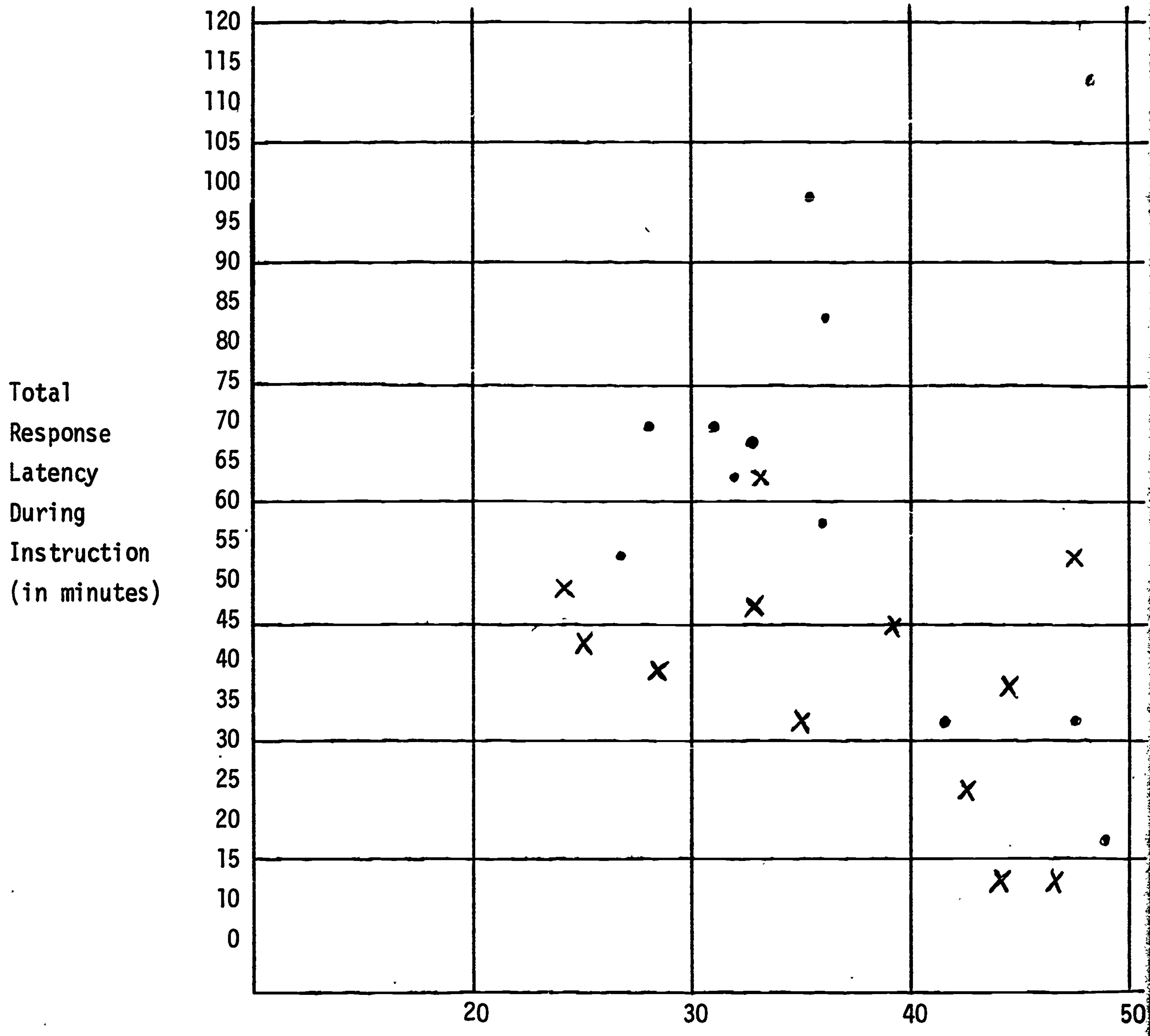
Although the treatment comparisons presented in this paper did not show statistically significant differences in learning, there was a very strong difference in instructional time for the two treatments. The response latencies also show rather striking differences between the two treatment groups and hold some promise for directing future research. The anticipated advantage for gradient feedback over full-response feedback did not materialize in this study. We are well aware that additional investigations will be required before discarding the theoretically sound idea of providing learners with a gradient feedback.

Because of the problems encountered with remote locations it was not considered advisable to engage in further statistical analysis of the data although they do suggest a trend. Silberman, Melaragno, Coulson and Estavan (1961)

Table 5

Correlations Between Retention Test Scores (2 weeks) and
Pretest Scores, Response Latency during Instruction,
Total Responses during Instruction Teaching Time, Posttest Score,
Response Latency during Posttest, and Response Latency
during Retention Test for Each Experimental Treatment

	Correlations Between Retention Test Scores and:						
	Pretest Score	Response Latency: Instruction	Total Responses: Instruction	Instructional Time	Posttest Score	Response Latency: Posttest	Response Latency: Retention
Gradient Feedback (n=12)	.209	-.229	-.161	-.193	.523	-.633	-.620
Full-Response Feedback (n=12)	.462	-.506	-.264	-.389	.815	-.203	-.499



Gradient Feedback . r = .229

Full-Response Feedback x r = .506

Fig. 2. Scatter diagram of retention test scores and response latency during instruction for subjects in the gradient feedback and full-response feedback treatments.

conjectured that some measures such as response latency are more appropriate than error rate for making certain decisions within a program. Postman and Egan (1949) point out that reaction time remains a sensitive measure of the readiness of an organism to respond. Using data of this kind has always been a difficult process because of the technical problems involved in measuring response latency and feeding the information back into the operating system for decision-making purposes. However, with the development of computer-assisted instruction and the speed and flexibilities of such systems, this information is readily available and can easily be used for making such decisions. It is the intent of the authors to continue investigating these variables which seem to hold promise for improving learning with computer-assisted instruction.

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Appendix A

Segments Used for Experimental Treatments

PRÉCIS OF FLOW CHART

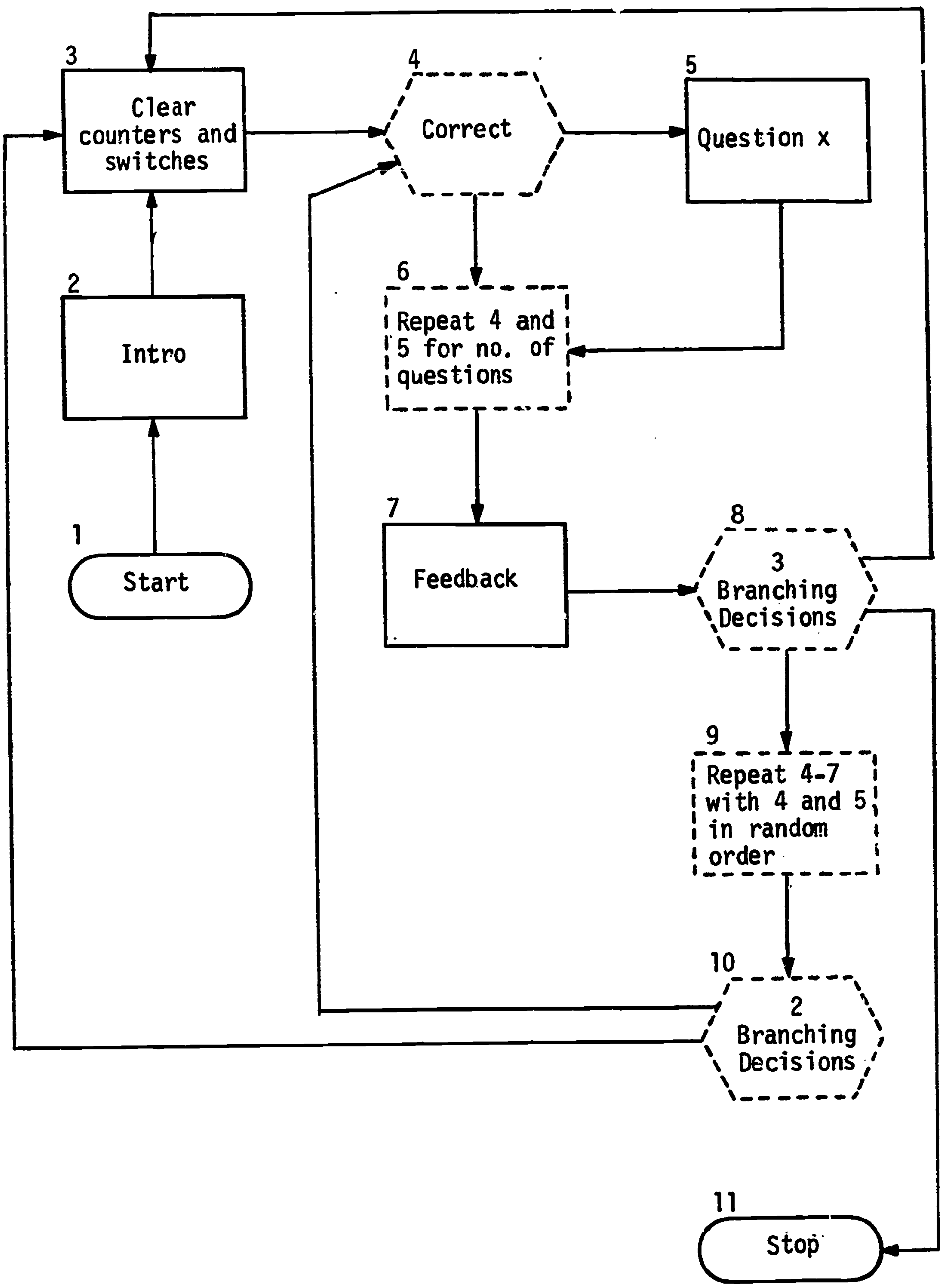
Student receives introduction consisting of examples, then counters and switches are cleared. Paired-associate items are presented. Those pairs missed are presented in random order a second time; any of these pairs that are missed are presented for a third time in the first random order, etc. This continues until a correct response has been made to all items on the first attempt. A test is then given which consists of presenting the states in the first random order. The only difference between the segments is the analysis and feedback--pa0 or kw.

Key to Flow Chart

1. Start
2. Introduction examples of paired-associate items
3. Clear counter and switches to be used in remainder of program
4. Branch depending upon whether or not paired-associate item was answered correctly
5. Paired-associate item
6. Repeat steps 4 and 5 for 50 items
7. Number acquired, number presented, number of responses, time of day, and response latency typed by the system on the student terminal
8. Branch to a new random sequence of PA items, the test, or the end of the program depending upon counters and switches
9. Steps 4-7 are repeated with 4 and 5 in a new random order
10. Branch to first random order of PA items or test depending upon counters and switches
11. Stop

Appendix A

Flowchart of Courses Used for Experimental Treatment



Appendix B

Segments Used for Experimental Treatments

PRÉCIS OF FLOW CHART

This is a flow diagram of one decision and question sequence from the segments used in the experimental treatments.

If the student has already responded correctly to this question, the next question is presented via the decision part of the program.

If the student has not responded correctly, the question is presented.

If the student responds correctly, he goes to the decision part of the program and to the next question in that order.

If the student responds incorrectly, he is given feedback to assist him to respond correctly. If the student is on the test portion, the program proceeds item by item without feedback.

Key to Flow Chart

4.1 Decision point where next pair to be presented is determined.

4.2 Switch s1 is 0 if this question was answered correctly

5.1 rd, ty

5.2 Counter 3 counts the pairs presented switch s1d is used to record if S answered correctly on first response

5.3 Question presented

5.4 Response latency stored in x2 number of responses accumulated and stored in c4

5.5 Is correct answer matched?

5.6 Is student in last sequence through pairs (test)

5.7 Feedback is given on incorrect response

5.8 Records the fact that student has been through this question before in this sequence

5.9 Has student responded to this question before in this sequence?

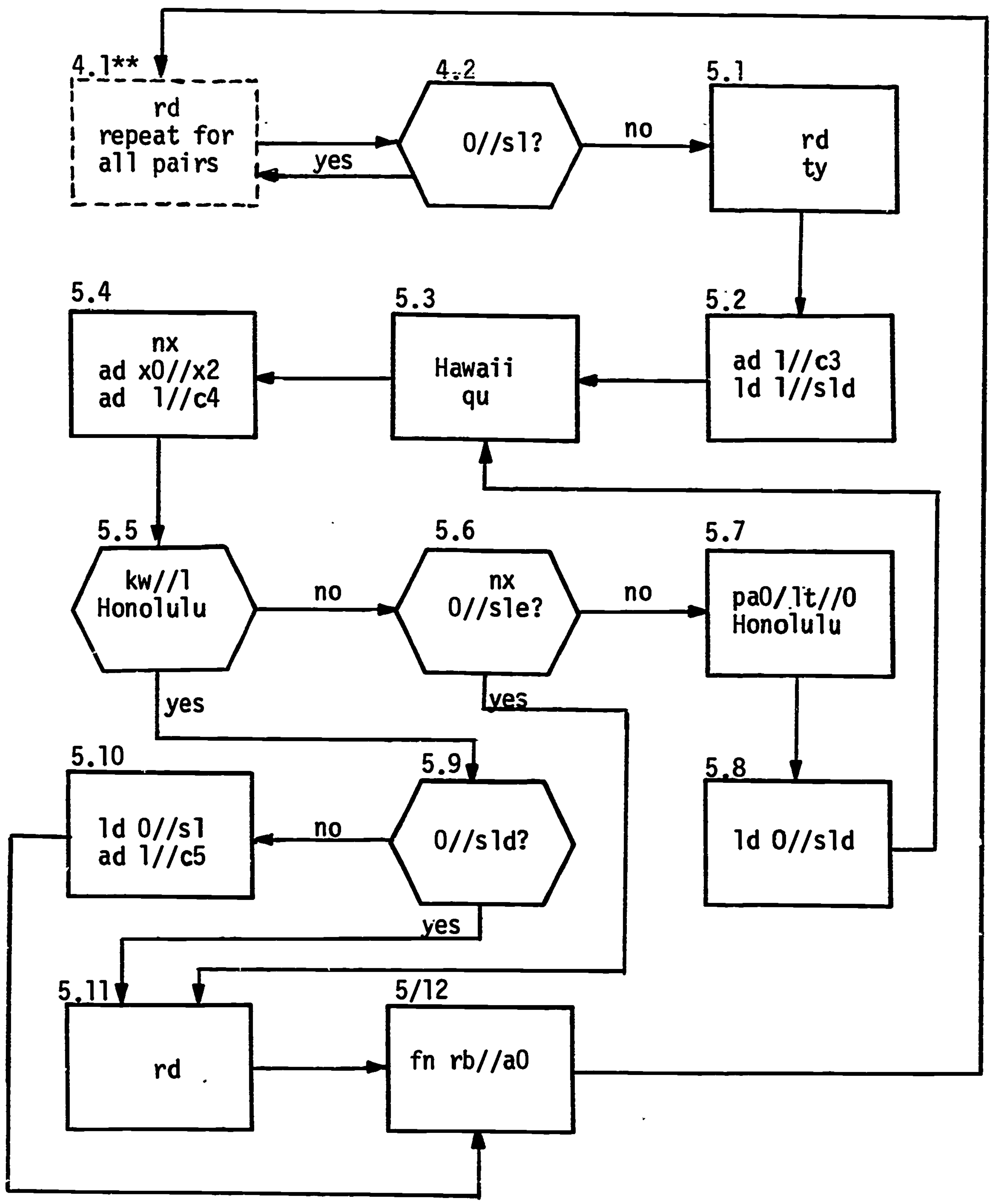
5.10 0 is loaded in s1 if pair acquired, counter 5 counts pairs acquired

5.11 rd

5.12 Return branch to decision part of program

Appendix B*

Flowchart of Student-System Interaction within a Question Block



*This charts the flow within block 4 and 5 in Appendix A.

**The programming within each block is presented in Appendix C and D.

Appendix C

Operand Codes, Arguments and Explanations for One Question Block for Presenting Individual Stimulus Item in the Experimental Course

from PA1

	Label	Op Code	Argument	Explanation
5.1	aa	rd		
		ty	,,linefeed linefeed,,	Spacing between question - 2 linefeeds
5.2		ad	1//c3	#pairs presented (trials)
		ld	1//sld	switch is 1 if S has not responded once to qu; controls branching in qu block
5.3		qu	Hawaii	Stimulus presented
5.4		nx		
		ad	x0//x2	x2 used to accumulate and display response latency from x0. (responses) total attempts to respond
5.5		fn	kw//1	one keyword will be searched for
		wa	Honolulu	correct answer
5.9		br	qu1//sld//0	branch to decision pt for another question if 1 in sld
5.10		ld	0//s1	switch is 0 if pair has been acquired
		ad	1//c5	number of pairs acquired
5.12		fn	rb//a0	branch back from subroutine
5.6		nx		
		br	qu1//slc//0	slc is 1 if S has not acquired all pairs. Controls branching during final test branch to next qu if 0 in slc

	Label	Op Code	Argument		Explanation
5.7		fn	pa0//15//0	ty,, kw//0x	answer is analyzed by pa0 and feedback of matched letters, -, & _.
		wa	Honolulu	ty,,	correct answer
5.8		ld	0//sld		0 in sld
5.11		rd			
5.12		fn	rb//a0		return branch from subroutine

Appendix D

Operand Codes, Arguments, and Explanations for One Decision Block for Controlling the Presentation of Individual Stimulus Items in Experimental Courses

	Label	Op Code	Argument	Explanation
4.1		rd		
4.2		br	qu1//s1//0	branch to next qu if this item acquired
5.1		fn	sb///qu1//a0///aa	branch to subroutine and then next qu

Appendix E

Sample of Student-System Interaction on Typing Test

Type the following sentence as soon as the green proceed light comes on; EOB when you finish:

My skill will improve quickly if I execute my job with zeal and vigor.

My skill will improve if I execute my job with zeal and vigor.

TIME: 34.64 ACCURACY: 89

Appendix F

Raw Data from Partial-Answer Processing and Keyword Experimental Groups

Subjects	Typing	Pretest	Posttest	Posttest Response Latency	Retention Test	Retention Test Response Latency	Total Teaching Time in Minutes	Total States Presented	Total Response	SOS
Partial-Answer Processing										
w1470	.94	28	37	24.34	29	45.17	92.2	82	127	66
w0931	2.44	09	48	13.59	36	40.90	94.1	97	194	76
w1449	2.86	41	50	9.03	49	9.19	29.9	59	70	68
w1453	2.16	07	39	10.75	36	16.45	131.8	131	262	63
L1646	1.64	13	40	10.50	32	10.74	118.4	152	288	74
L0925	4.17	09	46	9.40	49	7.70	160.7	128	267	73
w1778	.99	08	38	21.60	35	18.81	149.0	114	246	79
L0983	2.09	25	45	7.36	42	16.62	56.5	78	121	83
L1757	1.23	18	46	25.26	33	28.85	101.4	109	183	79
w0661	2.27	32	44	18.89	48	5.86	65.8	73	103	77
w1784	1.23	10	41	20.77	28	14.65	112.6	102	208	67
w1795	.54	35	45	25.39	26	31.97	72.2	67	96	66
Keyword										
w0617	1.27	25	47	16.66	45	14.47	59.6	79	111	56
w1448	2.78	27	49	10.89	43	8.15	49.7	74	106	74
w1469	1.23	32	48	16.75	35	17.07	54.5	78	106	74
L1775	3.85	01	47	10.12	48	5.43	129.3	203	378	76
L1725	2.54	08	33	11.83	25	9.98	102.3	167	288	72
L0954	2.13	15	46	8.32	39	10.69	80.4	110	172	69
L1644	2.85	02	44	10.68	33	12.24	121.0	153	266	63
L1634	1.02	12	42	14.57	33	13.26	81.4	105	163	76
L1081	2.04	09	41	9.34	28	13.82	87.8	138	232	87
w0615	2.28	44	47	10.34	47	16.58	28.8	58	70	79
w0627	4.79	35	50	7.85	45	6.10	31.9	65	82	81
w1781	1.85	16	41	13.74	24	24.22	82.9	97	162	66

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RELATIVE EFFECTIVENESS OF VARIOUS MODES OF STIMULUS PRESENTATION THROUGH COMPUTER-ASSISTED INSTRUCTION

Donald W. Johnson and Karl G. Borman

The question of which mode of presentation results in the greatest amount of learning in the shortest period of time has been with us for many years. With the advances made in technology and instructional media, this question has taken on even more importance than it has in the past. Computer-assisted instruction has found itself involved just as deeply in the question as the more traditional methods of teaching. An author writing materials for CAI is confronted with four modes of presentation. His choices are among the typewriter output, audio tape messages, 2 x 2-inch photographic slides and static displays (static displays are usually in the form of papers, booklets, or three-dimensional models). In some instances, these choices are determined by the subject matter being presented (i.e., when presenting stimulus material to test spelling ability, an audio message is the logical choice). However, the presentation mode is not always so well defined.

The purpose of this study is to determine the relative effectiveness of the various modes of presentation on total time for subjects to complete the course and on competence as determined by a posttest score.

As early as 1912, the question of which mode of presentation had the greatest effect on learning was being investigated. Henmon (1912) surveyed the literature at that time and found that an auditory presentation, regardless of subject matter, was superior to a visual presentation in immediate memory of adults. Krawiec (1946) found that the visual mode of presentation was superior for learning syllables and nouns. Locklard and Sidowski (1961) and Van Mondfrans and Travers (1965) found the same trend in their results.

The majority of the most recent research indicates that visual presentations are more efficient than auditory presentations. But, Wechkin (1962), after surveying the literature, still found that there was much disagreement as to the most efficient modality.

On the basis of the literature, there seems to be a strong, but not conclusive, indication that a visual mode of presentation would be significantly superior to an audio mode of presentation. It would then follow that the typewriter-output mode and the static display mode would tend to produce more effective and efficient learning than the audio output mode of presentation.

There are, however, other findings which are relevant to this study, all of which are not in agreement. Hansen (1966) cites three studies which show that the use of CAI results in a significant saving in instructional time without any loss in achievement when compared to conventional teaching methods (programed text or standard text).

Lewis (1965) in comparing two modes of visual display, one given via CAI and the other given by booklets, found no significant differences among mean completion times or among posttest scores.

Studies by Wodtke and Gilman (1966) and Wodtke, Gilman and Logan (1966) showed that CAI presentations took significantly more time to complete than programed text versions, while there were no significant differences in amount learned. In this study all of the material was presented by typewriter output. This led Wodtke (1967) to suggest that the increase of time for the CAI group may be due to the slow type-out rate of the typewriter which is slower than the average reading speed of the typical college student. He goes on to state (page 8):

> All other things being equal, by employing an interface which would decrease instructional time by 25 per cent without reducing the amount learned, four students could be taught for every three by means of a typewriter interface.
>
> From the college student's point of view, learning at a typewriter terminal is not self-paced instruction since he must slow down his normal rate of work. Pacing instruction below a student's optimal rate could produce boredom, negativism, and avoidance of CAI as an aid to learning.

Based on these findings, it would follow that the static display mode of presentation would take significantly less time and result in just as effective learning as the typewriter-output mode of presentation since the static display mode presents a paragraph of material to a student at a time and allows him to proceed at his own pace.

Method

Materials

Course material chosen for this study was a physics sequence, "Working With Units." It is a basic physics series designed for vocational-technical students who have finished high school and have a limited background in mathematics and physics. The sequence originally contained 55 frames of instructional and remedial material complemented with 9 slides. The sequence was designed so that all subjects received all of the material. Each frame included a question to provide for student interaction. All of the material within the sequence, with the exception of the slides, was presented via typewriter output. This version of the "Working With Units" sequence could be considered the core of the experimental course and will hereafter be referred to as the type mode.

In order to provide for a variation in stimulus modes, two other versions of the course were created. The material from 16 frames of the original 55 frames was transcribed word-for-word on audio tape to provide the audio mode of presentation. The 9 slides and the questions for each frame remained the same as for the type mode.

The display mode version of the sequence incorporated a booklet containing a written copy of the 16 frames that was recorded on audio tape for the audio mode. This group also viewed the same slides and answered the same questions as the other two groups; only the instructional material was altered through a change of presentation mode.

Subjects

The Ss consisted of 90 upperclassmen majoring in education and taking Instructional Media 435 at The Pennsylvania State University during the Fall Term, 1966. Each S in the Instm. 435 class was required to spend one hour at the CAI student station. The Ss were randomly assigned to one of four groups. (Due to computer failure and scheduling problems, the final groups did not contain equal numbers.) None of the Ss possessed a background of study in mathematics or physics prior to the treatment.

Procedure

Type Mode. The S signed on the course, the computer typed out instructions followed by questions. After the S typed his answer, the computer proceeded by typing material to the S, showing slides, typing questions, etc., until the lesson was completed. The S was immediately tested on his knowledge by a 15-item, multiple choice, computer-administered test. Total instructional time and test scores were recorded.

Audio Mode. Ss who received instruction through the audio mode heard the same material that the Ss in the previous mode read from the typeout. Ss could repeat each message as often as desired. They also received some typed material and slides which were common to all groups. When finished, they took the same computer-administered test. Total instructional time and test scores were recorded.

Display Mode. Ss in the display mode had a booklet containing all of the messages heard by the above group. Instead of hearing the messages as the above group, the typeout instructed them to read the proper page of the booklet. This group also received the same typed material and slides as the above groups. The same computer-administered test was taken by this group and their total instructional time and test scores were recorded.

Control Group. Ss in the control group received no instruction, but took the same computer-administered test as the above groups. Only their total test scores were recorded.

Findings

Table 1 shows the means and standard deviations of the posttest scores for all groups.

An analysis of variance procedure gave the results shown in Table 2. The F-ratio was significant beyond the .05 level of confidence. Sheffé's procedure for multiple comparisons (Sparks, 1963) showed that the audio, type, and display modes of presentation were all significantly superior to the control group concerning posttest scores. There were no significant differences between the audio, type, and display modes.

Table 1

Means and Standard Deviations of Posttest Scores
(Maximum Possible Score 15 Points)

Mode	N	Mean	S.D.
Audio	16	13.00	1.21
Display	12	11.67	2.19
Type	12	11.17	2.21
Control	50	8.90	2.30

Table 2

Analysis of Variance for Posttest Scores

Source	d.f.	Sum of Squares	Mean Square	F-Ratio	
Treatment	3	246.07	82.02	18.14	($P < .01$)
Error	86	388.83	4.52		
Total	89	634.90			

Table 3 shows the means and standard deviations of the mean completion times for the audio, display, and type modes of presentation.

Table 3

Means and Standard Deviations of Completion Times for CAI Program

Group	N	Mean (in seconds)	S. D. (in seconds)
Audio	16	3548.81	954.54
Display	12	3454.83	731.02
Type	12	3778.42	762.24

An analysis of variance procedure, however, did not yield a significant F-ratio (see Table 4).

Table 4

Analysis of Variance for Completion Times (in seconds)

Source	d.f.	Sum of Squares	Mean Square	F-Ratio
Treatment	2	672,410	336,205	< 1.0
Error	37	25,936,640	700,990	
Total	39	26,609,050		

This finding suggested to the authors that there may have been too much overlap between the type mode and the other modes since 39 out of 55 frames were common to all groups in stimulus mode. This may have hidden any mean differences in completion time. In order to remedy this situation, the authors decided to run the experiment again, this time increasing the number of frames containing variable modes of presentation.

Method

Materials

The basic course on "Working With Units" was again used. However, the remedial frames were removed from the program leaving 19 instructional frames which were constant in content for all groups. In this study all frames were presented under each of the modes, audio, static display, and type. This was to eliminate the common "typed" frames which were used in the previous study.

The control group was eliminated from this study. The data from the control group in the first study was considered to be representative of the general population of education majors from which the sample was drawn, and this data was used for succeeding studies.

In its place a new group was formed. This group received all of the instructional material on 2 x 2-inch photographic slides. This material was identical to that contained in the audio tape and in the static display booklet. This group also saw the 9 slides common to all groups and answered the questions in the same manner, i.e., by typing them on the typewriter keyboard. This group also received the computer-administered posttest.

Subjects

The *Ss* consisted of 87 upperclassmen majoring in education and taking Instructional Media 435 at The Pennsylvania State University during the Winter Term, 1967. Each *S* in the Instm. 435 class was required to spend one hour at the CAI student station. The *Ss* were randomly assigned to one of four groups. The *Ss* did not have a mathematics or physics background.

Procedures

The procedures were the same as previously described.

Findings

Table 5 shows the means and standard deviations of the posttest scores for all groups. The control group is the same group that was used in the previous study.

An analysis of variance procedure gave the results shown in Table 6. The F-ratio was significant beyond the .05 level of confidence.

Sheffé's procedure for multiple comparisons showed that the audio, display, type, and slide modes of presentation were all significantly superior to the control group's mean posttest score. There were no significant differences between the audio, type, and slide modes of presentation.

Table 7 shows the means and standard deviations of the mean completion times of the groups.

Table 5

Means and Standard Deviations of Posttest Scores of CAI Program (Maximum Possible Score: 15 points)

Mode	N	Mean	S.D.
Audio	20	12.15	2.13
Display	23	12.26	1.76
Type	24	11.62	1.64
Slide	20	11.75	2.20
Control	50	8.90	2.30

Table 6

Analysis of Variance for Posttest Scores

Source	d.f.	Sum of Squares	Mean Square	F-Ratio	
Treatment	4	300.28	75.07	17.42	($P < .01$)
Error	132	568.86	4.31		
Total	136	869.14			

Table 7

Means and Standard Deviations of Completion Times

Group	N	Mean (in seconds)	S.D. (in seconds)
Audio	20	3319.60	1147.65
Display	23	2674.04	565.64
Type	24	3003.79	1011.68
Slide	20	2885.60	782.52

An analysis of variance test did not yield a significant F-ratio (see Table 8).

Table 8

Analysis of Variance for Completion Times (In seconds)

Source	d.f.	Sum of Squares	Mean Square	F-Ratio	
Treatment	3	4,623,370	1,541,123.30	1.9024	(P ∠.20)
Error	83	67,238,560	810,103.13		
Total	86	71,861,930			

It should be noted that the obtained F-ratio in this study is larger than the one reported in the previous study.

Implications

The purpose of this experiment was to decrease instructional time on-line through various modes of presentations without any decrease in learning.

Special note should be taken of the findings indicating that the mean scores on the posttest for each experimental group was significantly higher than the mean score on the posttest for the no-instruction control group. It should also be noted that there were no significant differences on post-test score among the experimental treatments (audio, display, type, and slide). This was a consistent finding in both experiments. Therefore, regardless of mode of presentation, all groups were able to learn from the programed sequence.

The main purpose of the experiment, to decrease instructional time on-line, did not result in significant findings. However, there are some interesting tendencies which warrant further investigation. The authors feel that the large standard deviations obtained for the audio, type, and slide groups may be an important factor to reconsider. It is with this in mind that the authors plan to analyze each Ss performance on each frame in order to determine whether or not there are certain frames in the program that contribute an undue proportion to the standard deviation. After identifying these frames and rewriting them, the authors plan to further investigate the question of the relative effect of four modes of stimulus presentation through computer-assisted instruction.

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EXPRESSED STUDENT ATTITUDES UNDER SEVERAL CONDITIONS OF AUTOMATED PROGRAMED INSTRUCTION

Bobby R. Brown and David A. Gilman

The major focus in computer-assisted instruction today is on achieving the highest possible criterion performance in the shortest possible time for all students. To raise the question of student attitude toward computer-assisted instruction (CAI) or toward the instructional material presented via CAI may seem to many to be an irrelevant diversion from the major problems that challenge researchers in this area. Some attention has been given to the effect student attitude has on various performance measures (Eigen and Feldhusen, 1964; Wodtke, Mitzel, and Brown, 1966; Wodtke, 1965; Campbell and Chapman, 1965). These studies have been, for the most part, correlational investigations of the relationship between student attitude and such criteria as error rate in the program, time required to complete the program, or achievement score. In investigations of this sort the focus is still on "the highest possible criterion performance in the shortest possible time," and student attitude is seen as a relevant factor only insofar as it facilitates or interferes with the attainment of this goal.

On the basis of the above referenced studies, the following tentative generalizations seem to be justified:

1. Correlations between student attitude and performance measures tend to be positive but generally small, accounting for less than twenty per cent of the variance.

2. Due to the correlational approach taken in these previous studies little can be said about casual relationships between student attitude and performance.

3. It seems likely that student attitude is at least partially a function of the specific characteristics of the student-subject matter interface. If this is the case, various research findings may be to some extent system specific.

These generalizations seem to indicate that student attitude may not be a very important variable in short-range studies. However, when one considers long-range, routine use of CAI, student attitude may become considerably more important.

It is almost a truism in education that one outcome of a course or unit of instruction should be heightened student interest in continuing to learn more about the material being taught. In this context student attitude becomes important as one factor influencing "post-criterion" behavior. Also, in teaching minimally motivated students by CAI the long-range effects of student attitude may be of considerable importance.

Due to the rather general finding that student attitude and performance measures tend to be only moderately correlated, it cannot be assumed that a program which results in satisfactory criterion performance will necessarily result in a positive student attitude. If it is granted that student attitude may have significant effects on students' behavior after the period of instruction, it seems that a different approach to the study of student attitude is called for. Rather than studying the effect of student attitude on criterion performance, research should be directed to developing instructional programs which achieve both satisfactory criterion performance and positive student attitude. In the remainder of this article an experiment is reported in which student attitude (along with criterion performance, see Gilman, 1965) was treated as one of the outcomes of instruction.

Method

Subjects. The subjects were 66 ninth and tenth grade students in the college preparatory curriculum of State College Junior High School. All were naive with respect to educational experimentation procedures, and none had received instruction in physics. All Ss who began the experiment completed it.

Materials. Three programed courses were prepared. The subject of the three programs was dimensional analysis, or performing calculations involving units of measurement in working physics problems. The material of all three programs was identical with the following exceptions. The first program (CPF) was a CAI program utilizing contingent prompting and feedback. The second (KCR) was also a CAI program, but feedback consisted of the knowledge of the correct response. The computer typed the correct response two inches to the right of the student's response as in a typical programed text. The third group (text) received instruction which contained feedback material identical to the KCR program, but was presented by a programed text rather than by a computer controlled terminal.

Equipment. CAI equipment used by the CPF and KCR groups consisted of IBM 1050 terminals connected to an IBM 7010 computer. Instruction was teleprocessed a distance of 250 miles between the terminals, located at University Park, Pennsylvania, and the computer, located at Yorktown Heights, New York.

Design. Subjects were randomly assigned to three groups. The randomization was accomplished by the use of a shuffled stack of student data cards. Ss were pretested with the ten question pretest. No S answered more than three questions on the pretest correctly and most answered all questions incorrectly.

In all three groups the instruction was completed in a single session. All instruction was "stand alone" instruction in that no other instruction was provided other than the programed course. There were no difficulties with any of the equipment used during the experiment and the CAI groups experienced no down time or delays on the hardware.

Test

Student attitude was measured by a 40-item Likert-type scale, previously developed at The Pennsylvania State University CAI Laboratory (Brown 1966).

Student responses were scored 1 to 5, with 5 being the response which indicated the most favorable attitude toward the instruction. The maximum attainable score was 200. Kuder-Richardson formula-20 reliability obtained during an earlier study (Brown, 1966) was 0.885.

The attitude scale was administered to each S following the session of instruction.

Results

The responses of each student to the 40 items on the attitude scale were summed to yield one score for each student. The data were analyzed within a two-facto, treatments by sex, analysis of variance design. The only significant difference found was between the three-treatment means (F = 12.89, df - 2/62, $P < .001$). Scheffé's "S-test" (Sparks 1963) was performed on the three group means. This analysis showed that both KCR and CPF means were significantly different ($P < .01$) from the text group. The KCR and CPF were not significantly different from each other ($P > .05$). The results of these analyses are presented in Table 1. Previously reported performance data (Gilman, 19[illegible]) are presented in Tables 2 and 3 for the purpose of interpretation of attitude scores in relation to performance.

Table 1

Treatment Group Attitude Score Means, Standard Errors, F Value, and Results of Scheffé's "S-Test"

Group	$\bar{X}$	Standard Error	F	Scheffé's "S-test" Means Significantly Different from the mean in column 2 at .05	at .01
KCR	151.73	3.80	12.89	text	text
CPF	146.82	3.80		text	text
TEXT	125.67	3.90		KCR, CPF	KCR, CPF

Table 2

Comparison of Mean and Standard Deviations of Posttest, Retention Test, for On-line and Off-line Instruction in Dimensional Analysis

	10-item Pretest	40-item Posttest	40-item 6-week retention test
(A) Linear Programmed text			
(off-line)---------------	mean =1.2	20.6	17.0
(text n=22)	Sigma=1.1	6.6	6.3
(B) Linear Programmed text			
(on-line)---------------	mean =1.1	20.0	15.3
(KCR n=22)	Sigma=1.3	8.3	7.2
(C) Linear Coursewriter Program			
(on-line)---------------	mean =0.9	21.9	17.9
(CPF n=22)	Sigma=1.3	5.8	6.4
(D) F Ratio-------------------		<1.00	1.1
(E) Significance--------------	n.s.	n.s.	n.s.

Table 3

Comparison of Mean Instructional Time for On-line and Off-line Instruction in Dimensional Analysis

	CPF		KCR		Text
Instructional Time (Minutes)----	68		52		42
F Ratio		16.17		($P < .001$)	

Discussion

Groups KCR and CPF scored significantly higher on the attitude inventory than did the text group. There were no significant differences between the KCR group and the CPF group. There were no differences attributable to sex.

The differences between groups receiving computer-assisted instruction and instruction by programed text are similar to the anticipated results. As can be seen from Table 2, the differences in attitude scores cannot be attributed to differences in performance as the three groups did not differ significantly on either posttest or retention test performance. The groups did differ on the amount of instructional time required (see Table 3); however, in this experiment there seems to be no basis for explaining attitude in terms of time per se. Apparently the more positive expressed attitude toward computer-assisted instruction as compared to the attitude expressed toward programed texts is attributable to student preference for a novel automated instructional medium.

In the opinion of the authors the approach to the study of student attitude suggested in this report and illustrated by the above experiment should be employed, in conjunction with, if not instead of, the typical correlational approach, in research aimed at the development of instructional programs which achieve both satisfactory criterion performance and positive student attitude.

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REMEDIAL AND REVIEW BRANCHING IN COMPUTER-ASSISTED INSTRUCTION

David A. Gilman and Clara Gargula

Among the potential advantages of computer-assisted instruction (CAI) over programed texts are the branching and decision making capabilities in sequencing instruction. The factors which are important qualities for a good tutor should also be important for an automated instructional device. These are abilities to (1) adjust the instruction to each individual student's instructional needs, and (2) adjust instruction with respect to the learner's past experience.

When instruction is mediated by a computer, there exists a potential for taking advantage of the essentially statistical experiences of the learner by using it to determine the optimal tutorial teaching design.

Automated instruction has begun to receive new attention from educators, psychologists, and systems engineers with the introduction of computer-based program presentation. The potential of the branching capability in computer-assisted instruction has barely begun to be realized. The test of an automated instructional device is whether or not it can teach better or faster than conventionally employed methods. The possibilities of adjusting a program to take advantage of differences in learning characteristics of individual students needs to be investigated. If a student benefits from individualized instruction through branching, this advantage should manifest itself in higher achievement or less time required for students taught by branching, rather than nonbranching programs.

There are two basic kinds of branching strategy. The first is to branch the student to an alternate sequence of remedial material. The second is to provide the student with a review or re-exposure to material he does not yet understand.

The purpose of this investigation is to compare the effectiveness of branching strategies in an instructional program prepared for computer-assisted instruction with that of a nonbranching CAI program.

Rationale

The term "branching," when applied to an automated instructional device, is used to describe the way that the presentation of information and questions is varied to take advantage of the individual learning capabilities of the student. Branching enables those students who understand material to move ahead in a program and requires those students who do not understand to complete remedial instruction or review material before they may proceed with new material. Students who are having difficulty with some particular concept can be branched to appropriate instruction.

Smallwood (1962) defines a branching teaching machine as one which has the following characteristics: (1) information is provided to the student, (2) a set of questions is asked to ascertain whether the student understands the concept, (3) if the student does not understand a concept, he is provided with remedial questions, (4) if the student does not master a particular area of instruction, he must review that material, and (5) a criterion is used to decide what kind of instruction to present to the student.

Holland (1965) concludes that there is face validity in the proposition that differences in the past history of individuals and differences in their innate abilities are best accommodated by programs which adjust to the performance of the individual. Smallwood (1962) finds it obvious that the possibilities of changing a teaching program to take advantage of differences in the learning characteristics of students should be investigated.

Some programers (Crowder, 1962) make branching their principal tool. In Crowder's branching strategy, called intrinsic programing, the sequence of instruction is determined only by the responses to multiple choice questions. Skinner's original teaching machine (Skinner, 1958) branched in a way, since it repeated the incorrectly answered items at the end of each 29-item set.

Those programers who oppose branching consider changing the sequencing of a program to be rarely necessary. They conclude that optimal instruction will occur if a specific group of instructional frames are put together in a fixed sequence. They argue that the sequence of instruction which instructs one learner best should also best instruct all others. Thus, it would be unwise for a programer to omit or repeat segments of his program once an optimal instructional sequence had been attained.

In spite of the self-evident advantages of branching for adjusting programs to individual differences, Holland (1965) concludes that most studies find no advantages for branching. Holland (1965) cites seven studies by various experimenters and 10 others by Campbell (1961, 1962) in which no significant advantages were found for branching except that the conditions resulting in fewer items required less time.

Glaser, Reynolds, and Harakas (1962) used a branching program created from a small-step nonbranching program by combining items and providing additional cues and more detailed frames for those students who felt unsure of their response or made an error. Results indicated no difference in efficiency between the regular linear program and the branching program.

Some studies, however, indicate an advantage for adjusting the sequence to individual differences. Skinner's teaching machine (Skinner, 1958) automatically repeated incorrectly answered items at the end of each 29-item set. Although a low error-rate program was used, the repetition of missed items improved performance over the use of the program without repeating missed items.

Holland and Porter (1961) used three criteria for determining instructional sequence. These were (1) performance on diagnostic items, (2) errors in instructional items, and (3) the student's subjective evaluation of his readiness to advance to new instructional material. The branching group performed significantly higher than did a nonbranching group, as indicated by posttest scores.

In a test of mastery conducted by Schurdak (1965) 48 students learned a portion of Fortran by one of three methods; CAI, programed text, or conventional text. There were no significant differences in mean times required for the three groups to complete the course. The CAI group scored significantly higher than the other two groups. Diagrams accompanying Schurdak's report illustrate that of the three programs only the CAI program contained brancning.

Evans (1965) and Barlow (1963) found the controversy of "linear vs. branching" to be one which has no solution, since it seemed likely that linear and branching techniques served different functions.

The cases in which branching programs may provide an optimal learning situation are not yet known because of the paucity of studies involving branching strategies. A particular problem is the choice of criteria by which branching decisions are to be determined.

The implementation of a branching strategy to change a program so that it can provide remedial material or a review based on a decision criterion can be helpful to compensate for individual differences in students. While these capabilities are good guidelines for teaching, the value of including remedial or review material in a program must be judged from carefully controlled experiments.

Method

Subjects. The subjects were 42 students from the tile setting and plumbing programs of Williamsport Area Community College, Williamsport, Pennsylvania. These students were selected because they had not previously received instruction in physics. All were naive with respect to educational experimentation procedures.

Materials. Two versions of a CAI course used in a previous study were prepared. The subject of the programs was dimensional analysis, or performing calculations involving units of measurement in working physics problems. Subjects who responded incorrectly to a question were given feedback and required to answer the questions correctly before proceeding to the next item.

The two versions of the program differed in these respects: (1) the linear version contained only frames which were instructional; (2) the branching version also included remedial frames; (3) the content of each remedial frame was similar to the preceding instructional frame, but the remedial frames were branched to if and only if the student responded incorrectly to the instructional frames; and (4) if the student's response to an instructional frame was correct, the corresponding remedial frame was not a part of his instruction.

The branching program was also divided into three segments. Students with a high error rate on any segment were told that they had not done well on that part of the program and were required to repeat that segment until they could complete it with a low error rate.

Equipment. CAI equipment consisted of IBM 1050 terminals with audio-visual units. Instruction was teleprocessed a distance of 90 miles between the terminals located at Williamsport, Pennsylvania, and the computer located at University Park, Pennsylvania.

Tests. Two tests were constructed for the experiment. A 10-item pretest was devised to insure that Ss had no prior knowledge of dimensional analysis.

A 25-item criterion test was constructed containing items designed to measure both mastery and transfer. In an earlier pilot study the test yielded a KR-20 reliability of .80, an average item difficulty index of .676, a mean of 17.58, and an average item-total score correlation of .51.

Design. Subjects were randomly assigned to two proportional groups. The linear group consisted of 14 Ss and the branching group consisted of 28 Ss. The randomization was accomplished by the use of a shuffled stack of student data cards. Ss were pretested with the 10-item pretest. No S answered more than four questions correctly, and most answered all questions incorrectly.

The linear group received only the instructional frames of the program. The branching group received the instructional frames and corresponding remedial frame when an incorrect response was emitted during the instructional frame, but also reviewed segments of the program on which they had a high error rate.

Response latency, or the time required for the student to answer a question, was recorded by the computer for each response and was accumulated during the instructional period. The total instructional time was also recorded by the computer.

Immediately following the instruction, the 25-item posttest was administered to each subject.

All instruction was "stand alone" instruction in that no other instruction was provided other than the programed course.

Results were analyzed by means of an IBM 7074 computer utility program.

Results

The mean scores and standard deviations on pretest, posttest, responses, mean latency and total response latency are presented in Table 1.

There were slight differences in the means of the posttest favoring the branching group and a slight difference in instructional time favoring the linear group. These small differences were not statistically significant ($P > .10$). Apparently, the branching strategy was not an important factor in the learning of the material.

One important factor in comparing the programs was the number of responses required in the program. Table 1 shows the mean number of responses required by each group to complete the program. The difference in the means of the group were significant ($P < .001$). Clearly, more responses were required by the branching group than by the linear group. Although the branching group required more responses to complete the program, there was no instructional gain.

It is interesting to note that although the branching group required more responses to complete the program, the mean response latency was less than that of the linear group, so that the means of the total accumulated latencies for the two groups were not significant ($p < .10$). The lower latencies probably resulted from a greater amount of practice in using the terminal interface.

Discussion

The major conclusions of the study may be summarized as follows:

1) No differences in learning were obtained for a CAI program which incorporated instructional frames, branching to remedial frames, and review of program segments over a program which presented only instructional frames.

2) As a result of a criterion established by the programer, the students in the branching group required significantly more responses to complete the program. However, this learning strategy resulted in no noticeable gains in learning.

Table 1

Comparison of Means and Standard Deviations for Linear and Branching Instruction in Dimensional Analysis Achievement Scores

		10-item pretest	25-item posttest	Numbered Responses	Time	Mean Response Latency	Total Accumulated Latency
(a) Linear n=14	mean =	1.03	15.07	42.14	73.29	36.14	1523.22
	Sigma =	0.06	0.96	9.09	56.43	1.93	105.50
(b) Branching n=28	mean =	1.33	15.11	55.56	74.30	28.78	1596.22
	Sigma =	0.13	0.96	6.27	65.67	1.63	108.26
(c) t =		1.58	<1.00				
(d) Significance				3.42**	<1.00	1.61	≤ 1.0

**Significant at .001 level

3) Although the branching group required significantly more responses to complete the program, the mean response latencies of the linear group were lower than those of the branching group. Thus, there were no differences in the total accumulated response latencies for the two groups.

Conclusion

The results of the present study appear to be consistent with the results of Holland (1965), Campbell (1961, 1962) and Glaser (1965) in that no advantages were found for a branching strategy.

The results are not consistent with those found by Skinner (1958) and Holland and Porter (1961). Evans (1965) and Barlow (1963) have found the controversy of "linear vs. branching" to be one which cannot be answered unequivocably, since the two instructional techniques serve different functions.

The results of this study indicate that if branching is to be used to advantage in computer-assisted instruction, there must be a thorough investigation of those situations where it facilitates learning. Also, research needs to be implemented to determine the criteria for branching decisions.

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NUMERICAL AND VERBAL APTITUDE TESTS ADMINISTERED AT THE CAI STUDENT STATION

Joseph L. French

The major objective of the project reported here is to develop highly reliable tests of numerical and verbal aptitude for use with vocational and technical school students which can be administered and scored by a computer in relatively short periods of time. By utilizing a computer program, it is anticipated that a few items at the appropriate level of difficulty can be presented to each student. The student's response to each item is evaluated as soon as it is presented so that additional items which are too easy or too difficult for that student can be eliminated and items near the student's threshold of understanding can be presented in greater frequency than in traditional tests. Such procedure should reduce the number of items administered and increase the reliability of the measurement.

A long range goal is to develop tests which can be used to predict the most desirable size of step interval to be used in other programed instructions. Students with high aptitude may be immediately channeled into programs with larger steps than students with low aptitude in a particular area.

Rather than construct and validate new items, items from the Henmon-Nelson Tests of Mental Ability[1] have been selected for experimentation. These items were selected because their validity has already been established and they are presented in order of increasing difficulty in the existing forms of the test. The investigator is a co-author with Martin Nelson for the primary form of the Henmon-Nelson Test which is in preparation and a verbal agreement has been obtained from the publisher for use of the items from the high school and college levels in modified format.

The numerical test is based upon the quantitative items which appear in the High School Level Form A and Form B and the College Level Form A and

[1] Appreciation is expressed to Houghton Mifflin Company for permission to use selected test items in this study.

of the account. This program is written IN DAFT (Dual Autocoder-Fortran Translator) for the IBM 7074.

(4) Finally, an IBM 1401 program is used to multi-list as many printed copies of the account as may be required.

Examples of the output of these programs are given in the appendix.

Limitations

Since each item is presented visually, each test is limited to 80 items (or the capacity of the slide projector). After a student responds, quite a few seconds elapse before the next slide is projected. It is anticipated that upon conversion to equipment with a cathode ray tube, these limitations will be minimized.

Problems for investigation during the next reporting period

The pilot work suggests that the numerical items may be too difficult for the subjects in this project. If additional testing verifies this initial observation, more of the easy items will be substituted in the test, but the program will not be changed.

The initial testing suggests that four out of seven failures may not be enough to reliably establish the ceiling of one's performance. Additional off-line testing with the items arranged in the order now employed with on-line testing will be conducted to ascertain the effectiveness of the order.

Since the context of the items has been changed and new factors have been introduced with the mechanized process, it appears that additional study of the order of difficulty will be necessary. This study will be conducted in the next few months and the order of the items will be modified in keeping with the results.

It is possible to introduce a time factor in the program. Experimentation is being conducted to determine how long an item should be presented before an automatic failure is recorded.

Norms will be developed by administering both the verbal and numerical test on the computer and the regular edition of the College Level of the Henmon-Nelson to appropriate groups of subjects in a counter-balanced order. Interpretive scores will be developed for the modified tests based on performance and national norming of the Henmon-Nelson Test.

Correlational studies will be undertaken relating the scores on the numerical and the verbal tests with student success on course material.

CAI TIME ACCOUNTING AND USAGE ANALYSIS

Terry A. Bahn

Work is in progress to determine the feasibility of using an algorithm (similar to that used by the Penn State CAI installation for obtaining student performance summaries) (Bahn, 1966) to provide an accurate account of system usage. Such an account can be used to facilitate the efficient scheduling and use of the system, to provide a record for the payment of experimental subjects and system expenses, to determine hardware and software efficiency and to indicate how much of the total on-line time is being used by each user and for what purposes.

Previously, such an account was run with data cards punched from hand-kept log sheets. Besides the obvious tedium of card punching, this account was subject to human error both in the original logging and in the punching of the data. In addition, machine limitations made it necessary to run only one week's usage report at a time.

The set of utility programs presently in the final stages of debugging provide (1) a record of each period of on-line time including the course, time, location and use (Appendix A), (2) a record of the total time on-line for each user (Appendix B), (3) a record of the total time on-line for each course (Appendix C), and (4) a summary of time used at each location and (5) total time used by all terminal installations combined (Appendix D). There is one report for each month rather than for each week.

The basic algorithm for obtaining these reports is as follows:

(1) Sign-on and sign-off records are selected from the system log tape and written on another tape in the format: student number, course name, "1" if a sign-on and "0" if a sign-off, date and clock-reading. This program is run on an IBM 1401.

(2) These records are sorted by course, student number, date and time using the SORTM library program on an IBM 7074.

(3) Once sorted these records are submitted to another program which calculates the information given on the account and produces a tape copy

of the account. This program is written IN DAFT (Dual Autocoder-Fortran Translator) for the IBM 7074.

(4) Finally, an IBM 1401 program is used to multi-list as many printed copies of the account as may be required.

Examples of the output of these programs are given in the appendix.

Reference

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Appendix A

Course, Time, Location and Use of Each On-Line Period

CHAMBERS STUDIES (HOURS)		CHAMBERS STAFF (HOURS)		CHAMBERS DEMONSTRATIONS (HOURS)		CHAMBERS TERMINAL TESTING (HOURS)	KEITH JR. HIGH (HOURS)		ALTOONA (HOURS)	WILLIAMSPORT C.C. (HOURS)		SPECIAL (HOURS)
										SPINTRO	0.05	
										SPINTRO	0.05	
		SPPL	0.47									
ABPHYSICS	1.64											
ABPHYSICS	0.50											
AFPHYSICS	3.23											
AFPHYSICS	4.58									AFPHYSICS	0.20	
				ATOM	1.92							
				ATOM	0.38							
				ATOM	2.05							
				ATOM	0.04							
				ATOM	0.03							
				ATOM	0.26							
		ATOM	2.11									
		ATOM	3.14									
		ATOM	0.53									
ATOM	0.08											
ATOM	2.52											
ATOM	0.96											
		ATOM ATOM	3.23									
				ATOM OM	0.16							
		AUD	0.05									
		BIOCHEM	0.53									
		BIOCHEM	1.49									
		BIOCHEM	0.32									
				BIOCHEM	0.08							
BIOCHEM	0.35											
		BIOCHEM EM	0.08									
CALC	1.97											
				COG	2.01							
				COG	0.28							
		COG	0.53									
		COG	2.53									
				COG	2.31							
				COG	0.47							
		COG	0.53									
							COG	0.03				
							COG	0.30				
							COG	2.09				
							COG	0.79				
							COG	2.00				
							COG	1.04				
							COG	0.63				
							COG	2.01				
COG	3.35											
COG	2.15											
COG	2.81											
COG	3.28											
COG	0.42											
COG	0.67											
COG	2.59											
COG	3.11											
COG	2.98											
		COMPAT	0.52									
		COMPAT	0.23									

Appendix B

Total On-Line Time Per User

USER	HOURS ON LINE	PERCENT OF TOTAL HOURS USED	PERCENT OF TOTAL HOURS SCHEDULED
S 22	19.88	7.85	6.83
S 23	3.76	1.49	1.29
K 27	2.61	1.03	0.90
C 29	2.16	0.85	0.74
S 30	3.13	1.24	1.08
C 31	0.99	0.39	0.34
S 34	0.06	0.02	0.02
S 36	4.90	1.94	1.68
C 40	2.17	0.86	0.75
C 41	0.68	0.27	0.23
C 42	4.81	1.90	1.65
C 43	0.39	0.15	0.13
C 44	0.17	0.07	0.06
C 45	0.60	0.24	0.21
C 46	7.79	3.08	2.68
C 47	0.13	0.05	0.04
C 48	24.56	9.70	8.44
S 50	0.74	0.29	0.26
C 71	1.81	0.72	0.62
C 79	2.59	1.02	0.89
C 112	7.14	2.82	2.45
C 113	0.45	0.18	0.16
S 114	12.80	5.05	4.40
C 115	0.75	0.30	0.26
K 333	0.79	0.31	0.27
K 371	1.09	0.43	0.37
K 372	0.75	0.29	0.26
K 375	2.00	0.79	0.69
K 383	1.05	0.42	0.36
K 385	1.84	0.73	0.63
K 395	1.04	0.41	0.36
K 402	0.63	0.25	0.22
K 418	0.90	0.36	0.31
K 460	2.00	0.79	0.69
K 478	2.01	0.80	0.69
C 494	14.96	5.91	5.14
C 500	0.47	0.19	0.16
C 612	9.47	3.74	3.25
K 620	0.58	0.23	0.20
S 731	2.59	1.02	0.89
S 734	0.58	0.23	0.20
S 747	3.11	1.23	1.07
S 748	2.98	1.18	1.02
S 759	2.11	0.83	0.73
W 760	4.52	1.79	1.55
W 767	0.81	0.32	0.28
W 774	3.43	1.35	1.18
C 778	2.00	0.79	0.69
C 781	7.95	3.14	2.73
C 788	13.00	5.14	4.47
S 792	4.24	1.67	1.46
S 797	7.10	2.80	2.44
C 802	11.34	4.48	3.90
S 807	19.61	7.75	6.74
S 808	17.38	6.86	5.97
C 822	4.28	1.69	1.47
C 823	1.32	0.52	0.45
S 831	0.11	0.05	0.04

Appendix C

Time On-Line Per Course

COURSE	HOURS ON LINE	PERCENT OF TOTAL HOURS USED	PERCENT OF TOTAL HOURS SCHEDULED
AB PHYSIC	0.47	0.19	0.16
ABPHYSICS	0.56	0.22	0.19
ATOM	5.54	2.19	1.90
AUD	15.70	6.20	5.40
AUD C	2.17	0.86	0.75
AUD AUD	0.75	0.29	0.26
CALC	1.90	0.75	0.65
COG	8.21	3.24	2.82
CP	0.69	0.27	0.24
HAMATH	7.54	2.98	2.59
MAVMATH5	3.22	1.27	1.11
MOD MATH	0.90	0.35	0.31
MODMATH1	2.21	0.87	0.76
MODMATH5	0.78	0.31	0.27
MODMATH5X	1.02	0.40	0.35
MODMATH6	2.18	0.86	0.75
PIPER	0.16	0.06	0.05
PIPE2	4.96	1.96	1.71
SOS	0.45	0.18	0.15
SPA 430-X	0.18	0.07	0.06
SPA430-X	4.23	1.67	1.45
SPINTRO	0.61	0.24	0.21
SPPL	0.47	0.18	0.16
ABPHYSICS	2.14	0.85	0.74
AFPHYSICS	8.00	3.16	2.75
ATOM	14.04	5.55	4.82
ATOM ATOM	3.23	1.27	1.11
ATOM OM	0.16	0.06	0.05
AUD	0.05	0.02	0.02
BIOCHEM	2.77	1.09	0.95
BIOCHEM EM	0.08	0.03	0.03
CALC	1.97	0.78	0.68
CCG	38.92	15.37	13.37
COMPAT	3.28	1.30	1.13
CP	6.38	2.52	2.19
CP CP	0.20	0.08	0.07
DAPHYSICS	0.66	0.26	0.23
CRPHYSICS	1.62	0.64	0.56
DISPLAY SR	0.69	0.27	0.24
ED /SEL2 S	1.55	0.61	0.53
ED/SEL2	10.64	4.20	3.66
EDSEL2	0.03	0.01	0.01
HAMATH	4.06	1.60	1.39
JAMATH	3.56	1.41	1.22
JBMATH	4.53	1.79	1.56
JXMATH	1.06	0.42	0.37
MAG 8 MAG	1.25	0.49	0.43
MAVMATH5	1.01	0.40	0.35
MD1	5.97	2.36	2.05
MD2	1.77	0.70	0.61
MD2 2	0.36	0.14	0.12
MOD MATH1	3.27	1.29	1.12
MODMATH 1	0.30	0.12	0.10
MODMATH1	2.61	1.03	0.90
MODMATH5	0.16	0.06	0.06
MODMATH5 A	4.76	1.88	1.63
PA1	0.27	0.10	0.09
PIPER	0.14	0.06	0.05

Appendix D

Time Summary for Month

	CHAMBERS	KEITH JR. HIGH	ALTOONA	WMSPRT C.C.	SPECIAL	TOTAL
HOURS SCHEDULED	244.25	14.75	0.00	32.00	0.00	291.00
HOURS USED	227.29	17.12	0.00	8.76	0.00	253.17
PERCENT OF HOURS SCHEDULED	93.05	116.10	0.00	27.37	0.00	87.00
HOURS DOWN COMP. CENTER	1.25	0.62	0.00	0.00	0.00	1.87
PERCENT OF HOURS SCHEDULED	0.51	4.18	0.00	0.00	0.00	0.64
HOURS UNUSED	15.71	-2.99	0.00	23.24	0.00	35.96
PERCENT OF HOURS SCHEDULED	6.43	-20.28	0.00	72.63	0.00	12.36

TERMINAL ACCOUNTING FOR THE MONTH OF JUNE COMPLETE.